MASK, STRATEGIES AND INSPECTION TIME

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This thesis contains no material which has been accepted for the award of any degree or diploma in any university, nor any material previously published or written by another person, except when due reference to such material is made in the text.

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Abstract

This study evaluated a number of procedural problems in the Inspection Time research which had not previously been evaluated. Three problems appeared to be related to the backward masking stimuli and procedure used in the measurement of Inspection Time. In the course of the study three new masks were generated and evaluated for effectiveness and reliability in controlling effectiveness and reliability in controlling post-masking cues. The effect of these different masks on mean I.T. measure and on the I.T.-I.Q. correlation was assessed. The occurrence and nature of strategy use across different target-mask stimuli was examined, classified and documented. Finally, the extent and nature of practice effects was determined. All these procedural problems were found to be closely interrelated and all were shown to affect the measurement of Inspection Time. Results clearly indicated that the procedural aspects of the Inspection Time measure need to be standardised and controlled before the reliability and meaningfulness of the I.T.-I.Q. correlation can be fully realised.

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Chapter 1

Introduction

1. Introduction

1.1 Inspection Time

Definition: The time required by a subject to make a single observation or inspection of the sensory input on which a discrimination of relative magnitude is based (Vickers, Nettelbeck & Willson, 1972).

Individual differences in speed of mental functioning have long been of interest to researchers. In recent years, the theory that individual differences in intelligence are integrally related to differences in speed of information processing has received increased attention. In some measures like reaction time it would appear to be renewed interest and attention (Vernon, 1987) whilst in others, notably Inspection Time (I.T.), the interest is relatively new spanning only the last two decades (Nettelbeck, 1987).

One major aim guiding attempts to measure the speed of mental functioning has been to isolate some process sufficiently elementary to be relatively immune from the influence of higher cognitive activities, motivational or social factors (Vickers & Smith, 1986). The inspection time index proposed by Vickers, Nettelbeck and Willson (1972) is considered to measure the most elementary process in the hierarchy of human information-processing stages. In fact Nettelbeck (1987, p.295) considers I.T. to reflect a fundamental "temporal limitation to the rate at which information is initially taken in for processing". I.T., the only index of mental speed that does not involve a motor response component is held to tap individual differences in the speed of apprehension - "the quickness of the brain to react to external stimuli prior to any conscious thought" (Kranzler & Jensen, 1989, p.330).

The measurement of I.T. is based on a model of comparative judgement derived from a theoretical framework developed by Vickers (1970, 1979) to estimate the rate at which a subject can process sensory input and come to a decision. The model assumes that following sensory registration (in a two choice discrimination task) the individual collects or accumulates 'bits' of information favouring either decision in two separate short term memory stores. A decision is made when one of the stores accumulates sufficient information to reach a predetermined level of accuracy (Vickers, Nettelbeck & Willson, 1972). The model further assumes that the evidence builds up at a steady rate from a number of discrete samples or inspections, each taking a small constant period of time and contributing a variable amount of information. This processing occurs against a background of internal and external 'noise' in the visual system due to variable physiological sensitivities, the decisional bias of the individual, and the physical variability of the stimulus.

Vickers (1970) proposed that I.T. could be measured in a task that needed only a single inspection to reach a decision, provided that the observation (inspection) favoured the correct response and was equal to or exceeded the response criterion and that any delay associated with variable motor performance was eliminated.

Such a task was devised by Vickers, Nettelbeck and Willson (1972) and has been used extensively in subsequent research (Nettelbeck, 1987). The stimulus was presented to a subject tachistoscopically and consisted of two vertical parallel lines of different lengths. The subject's task was to determine which line was shorter and respond accordingly left or right on a response panel. The constraints of the task effectively controlled for internal and external 'noise' within the visual system. Exposure durations were controlled by a backward masking technique in which the two lines to be compared were rapidly overwritten by longer lines of equal length. According to their hypothesis, by using extremely brief presentations of visual stimuli and having an effective mask, the individual would not retain any vivid image of the visual stimulus in memory. Furthermore each discrimination would be based only on the immediate input, and further processing of each input, beyond the interval between target onset and mask onset (stimulus onset asynchrony SOA), would be curtailed by the mask. Vickers, Nettelbeck and Willson (1972) considered that they had produced a discrimination task with such minimal cognitive content that a decision could be made on the basis of one inspection.

Subsequently, a variety of stimuli have been developed in different modalities, viz visual, auditory, and tactile; each requiring different modes of presentation, different masking procedures and different forms of response. A comprehensive summary and evaluation of these studies has been presented by Nettelbeck (1987). Irrespective of the variations in specific discriminanda across studies, the estimation of the minimum time required to maintain response accuracy is central to all inspection time tasks.

The estimation of this measure is achieved by either of two basic psychophysical procedures: the method of constant stimuli or the method of limits. In the method of constant stimuli a fixed number of trials are presented at each of several specific exposure durations. These exposure durations are selected from a wide range within which the measure of I.T. is expected, and, then presented within a quasi-random sequence. The target stimulus duration at which the individual makes the specified number of correct responses is, therefore, the estimate of inspection time (Nettelbeck, 1987).

The other method commonly used is an "adaptive staircase" procedure, which is a modification of the method of limits. In this staircase procedure the stimulus exposure duration is lowered or raised according to the individual's performance within the constraints of a predetermined level of accuracy. Thus this procedure systematically "homes in" on the individual's measure of Inspection Time. The most frequently used versions of the adaptive method are the Parameter Estimation by Sequential Testing (PEST), developed by Taylor and Creelman (1967, cited in Nettelbeck, 1987) and the Sequential Estimation of Points on a Psychometric Function by Wetherill and Levitt (1965).

1.2 Inspection Time and Measured Intelligence

Although the Inspection Time measure was developed within an information processing framework, it was the reported correlation with intelligence measures (Nettelbeck & Lally, 1976) that brought I.T. to the attention of researchers seeking a reliable, yet easily accessible, measure of mental speed. The direction of research changed from determining the accuracy and reliability of the I.T. measure itself, to determining the size and significance of the I.T.-I.Q. relationship and establishing reliability for the measure of this relationship.

Early research findings, notably from Nettelbeck and his colleagues (Nettelbeck & Lally, 1976; Lally & Nettelbeck, 1977) and Brand (1981); Brand and Deary (1982) found I.T. to be more highly correlated (negatively) with 'g' than any other index of mental speed. Inspection Time was hailed as a culture fair test of intelligence by Brand (Brand & Deary, 1982) although to be precise, Brand did specify that it is the initial speed of sensory intake during the early stages of perception that determines the development of general intelligence.

More recent reviews of the I.T. literature, however, have been inconclusive and far more cautious (Deary, 1989; Lubin & Fernandez, 1986; Nettelbeck, 1987; Vernon, 1986). The factors contributing to this lack of consensus include: many studies with very small sample sizes, an unusually wide range of non-normally distributed I.Q.s, restriction of ability range, and the use of different I.T. apparatuses and psychophysical procedures (Kranzler & Jensen, 1989).

In a somewhat satirical paper, Longstreth, Walsh, Alcorn, Szeszulski and Marus (1986) suggested that the I.T.-I.Q. correlation shrinks as the year of publication moves forward. Nettelbeck and Lally (1976) found a correlation of -.92 between I.T. and WAIS P.I.Q. whereas by 1983, Vernon found a correlation of +.15 between the same measures. In fact Longstreth et al observed that the probable explanation appeared to be that as the sample size increased the I.T.-I.Q. correlation decreased. Certainly the Nettelbeck and Lally (1976) study had only 10 subjects whereas Vernon (1983) had 50 subjects. However, research by Mackenzie and his colleagues (Mackenzie & Bingham, 1985; Mackenzie & Cumming, 1986; Mackenzie, Bingham, Cumming, Doyle, Turner, Molloy, Martin, Alexander &

Lovegrove, 1989) would suggest there are other factors influencing the I.T.-I.Q. correlation outcome. Nevertheless Longstreth's study which had a sample size of 81 and normally distributed I.Q. measures on the Cattell Culture Fair Intelligence Test (Scale 3, Form A), in fact found a correlation of -0.44 between I.T.-I.Q. However, on the basis of an information-processing analysis of the components of the backward masking procedure and I.Q. tasks, Longstreth et al concluded that specific elements common to both, mediated this particular I.T.-I.Q. relationship. The common elements were feature analysis, selective attention and pattern recognition processes.

Thus, it was suggested that variation in I.T.-I.Q. relationship was not only due to small and heterogeneous samples but also to the extent of shared features between the particular I.Q. test and the particular masking paradigm. The greater the common elements the larger the I.T.-I.Q. relationship and vice versa.

Studies by Mackenzie and his colleagues at the University of Tasmania have shown that the I.T.-I.Q. relationship is also modified by the use/non-use of apparent motion strategies. Over a series of 5 studies the mean I.T.-I.Q. correlation is -.62 for cue non-users (n=95) but this correlation drops dramatically to -.16 for cue users (n=106). This finding is robust across differences in target-mask combinations; I.Q. measure; performance motor skills and age of subjects. It would appear that the mask is effective for some, but not all subjects and yet the accurate measurement of Inspection Time would appear to depend on a reliable masking procedure.

1.3 Visual Masking

Visual masking has been used extensively to investigate the functional hierarchies of the visual system. Through this procedure physiological mechanisms thought to underpin visuo-perceptual processing have been investigated and evaluated. Temporal stages of visual processing have been isolated and hypotheses regarding the structure and function of the visual system have been tested. Michaels and Turvey (1979) defined masking as "the phenomenon of perceptual interference that results when the temporally discrete, briefly exposed and unrelated visual fields are presented in rapid succession to a stationary observer".

Visual masking occurs when one visual stimulus interferes with the perception of another visual stimulus. In experimental parlance the masking stimulus (M.S.) interferes with the perception of the target stimulus (T.S.) although mutual masking can occur. In forward masking the M.S. precedes the T.S. whereas in backward masking the M.S. follows the T.S. Four spatially distinctive types of target and mask stimuli have been used to achieve visual masking effects (Breitmeyer & Ganz, 1976; Felsten & Wasserman, 1980; Kahneman, 1968). When the contours of the mask do not overlap but are contiguous with the contours of the target, paracontrast (M.S.-T.S. sequence) or metacontrast (T.S.-M.S. sequence) masking occurs. Masking by structure or pattern occurs when the structure of the target and mask are similar and the mask overlaps the contours of the target. When there is little structural similarity between the target and a randomly patterned overlapping mask, masking by noise occurs and finally masking by light occurs when the mask is a more intense flash of light, illuminating a larger area than the target. In practice, masking can occur with any of these four types or any combination of these types of target-mask stimuli.

The backward masking paradigm has been used extensively to estimate the rate of initial sampling from a prerecognition storage stage (Kahneman, 1968) to subsequent perceptual encoding and recognition stages in visual information processing models. It is in this context that backward masking is of vital interest and importance to I.T. research.

Visual backward masking has been investigated extensively over the last two decades. The research findings show that qualitatively different masking phenomena are observed under different experimental conditions (Turvey, 1973; Michaels & Turvey, 1979; Felsten & Wasserman, 1980).

Historically two alternative hypotheses have developed to explain how visual masking works by interruption or integration of the T.S. by the M.S. In the interruptive process the masking stimulus either interrupts the consolidation of the percept of the target stimulus or alternatively a visual image of the target stimulus is formed but the subject is interrupted before the information contained in that image is read into a more permanent store (Kahneman, 1968; Sperling, 1960).

The alternative view - the integration hypothesis - stresses the effect of masking on the sensory character of the visual representation itself. According to this hypothesis, when two stimuli follow each other in rapid succession they synthesize and the visual system treats them as a single stimulus (Kahneman, 1968), producing an effect similar to that produced by the double exposure of photographic film (Felsten & Wasserman, 1980).

There continues to be debate about the mechanism of masking, as to whether the degradation of the T.S. is achieved by either the interruptive or integrative effects of the M.S., or rather, whether these different effects relate to, and distinguish between different experimental conditions rather than different processes of masking. Felsten and Wasserman (1980) would argue that the experimental data from various psychobiological and psychophysical studies can be interpreted as providing evidence for only one process in visual masking, primarily involving sensory integrative mechanisms. The conclusion is presented as a "harmonisation of the masking problem. Different features (sensory codes) of identical neural responses, differ in their energy or time dependence. Since the sensory code is task dependent, task variation can cause a single integrative mechanism to lead to either time or energy dependent behaviour. On this interpretation, the variety and complexity of the behaviours exhibited in masking studies are then a joint consequence of the variety of sensory codes and the complexity of neural integration" (Felsten & Wasserman, 1980 p.329). Further, they suggest that backward masking limits the duration of availability of the sensory signal but does not intrinsically limit the amount of time available to process information. Within an integrative paradigm the backward mask limits the duration and information content of the target stimulus by preventing visible persistence - effectively an interruptive mechanism.

Research on visual masking has not only explored the mechanisms likely to underpin visual masking but it has also sought to determine the site in the visual system at which this phenomenon occurs. Visual masking effects have been shown to occur in (a) the peripheral pathway transmitting visual information from the eye to the brain; (b) central processes supporting feature analysis; and/or (c) central processes involving selective attention and pattern recognition (Longstreth et al, 1986).

The ongoing debate regarding site or locus of masking is of interest to researchers of the I.T.-I.Q. relationship because they have based their theory on the centrality of processing (Nettelbeck, 1987). Felsten and Wasserman (1980) provide evidence that integrative processing can occur both centrally and peripherally and interruptive processing has been identified in central processing.

Some research has addressed the locus of masking because this is perceived as being vital to the concept of the centrality of the I.T. measure (Nettelbeck, Hirons & Wilson, 1984). Nettelbeck (1987) has referred to difficulties in interpreting results and making comparisons across studies unless the locus of masking is known and known to be consistent.

Considering the vital role played by the backward masking paradigm in the measurement of Inspection Time, it seems remarkable that there are so few studies evaluating the operative/procedural effects of the backward mask within the I.T. procedure.

Studies by Mackenzie and colleagues in Tasmania (Mackenzie & Bingham, 1985; Mackenzie & Cumming, 1986; Mackenzie, Bingham, Cumming, Doyle, Turner, Molloy, Martin & Lovegrove, 1989) are among the few to consider the procedural difficulties encountered using the backward masking technique. They have documented the effects of use of apparent motion, apparent depth and other strategies in creating variations in mean I.T. measurement and I.T.-I.Q. correlation within and across experimental procedures.

In fact a review of perception studies involving techniques that were similar to the masking techniques used in most of the I.T. experiments revealed a body of evidence not being considered by I.T. researchers.

This evidence suggests that the backward masking technique may not prevent further processing of the target stimulus (Felsten & Wasserman, 1980). Schultz and Eriksen (1977) found that controlling target processing time by using a visual-noise backward mask was methodologically inadequate unless specific basic control operations such as simultaneous presentation of target and mask was used to assess the effectiveness of the noise field. Under certain conditions the noise field enhances the target stimulus as in trace summation. According to Navon and Purcell (1981) citing Eriksen and Eriksen (1972), trace summation occurs by the target stimulus persisting in the visual system for some time after its offset and after the mask onset. During this time the energy in the mask and the decaying persistence of the target summates. Eriksen (1980) considers that visual masking does not meet the criteria of sound experimental technique. Those criteria are that "the experimental manipulations be clearly understood, unambiguous and non controversial as to their effects" (Erikson, 1980 p.89). The ongoing debate on the mechanism of masking and the effectiveness of masking lends support to the disquiet felt by Erikson. It has been clearly demonstrated that the specific nature of the target-mask interaction may either enhance or degrade the target (Erikson, 1980; Felsten & Wasserman, 1980; Ward & Ross, 1977; Wolford, Marchak & Hughes, 1988).

From the viewpoint of Inspection Time measurement, the inexactness of the backward masking technique would appear to introduce unspecified unreliability and variation in the Inspection Time measure due to the specific nature of the target mask interaction.

It would appear that the specific nature of the target-mask condition may preclude I.T. measurement comparison across studies, unless the mask used is consistently effective in controlling availability of information from the target.

Nettelbeck (1987) acknowledged that some subjects are able to achieve unusually high levels of accuracy in I.T. measure at very brief target durations by using subtle post masking cues in the display which give rise to apparent movement or changes in brightness.

As early as 1982, Nettelbeck recognised that mean levels of the I.T. measure were influenced by specific experimental features such as stimulus intensity or the efficiency of the backward mask.

Although these findings are considered to introduce unspecified unreliability into the I.T. measurement, Nettelbeck (1987) appears to consider them a sufficiently infrequent occurrence as to disregard their impact.

Among the factors acknowledged to influence the I.T. measure are those which appear to pertain directly to the efficiency of the mask. Evidence of apparent motion cues (Mackenzie & Bingham, 1985; Mackenzie & Cumming, 1986; Mackenzie et al, 1989; Nettelbeck, 1982, 1987); practice effects (Ward & Ross, 1979; Turvey, 1973; Nettelbeck, Evans & Kirby, 1982; Wolford, Marchak & Hughes, 1988; Irwin, 1984); and use of strategies (Mackenzie & Bingham, 1985; Smith, 1986; Egan, 1986) suggests that the backward masking techniques as used in I.T. measures, are not as reliable and efficient as the I.T. researchers expect.

1.4 Factors Affecting Mask Efficiency

1.4.1 Practice Effects

It has been well established in the perception literature that practice, within a backward masking paradigm, facilitates improved performance (Ward & Ross, 1977; Turvey, 1973; Wolford, Marchak & Hughes, 1988). In the course of the experiment subjects may show a nonspecific adaptation to the task, thus improving from a level initially depressed by the novelty of the situation. The explanation favoured by Turvey (1973) is that subjects develop specific strategies for processing the presented information more efficiently. In support of this interpretation, Ward and Ross (1977) cite data from Turvey (1973), and Schiller (1965) both of whom report that practice effects occur only in central masking. This finding suggests that the practice effects were not due to non specific adaptation to the task, because this type of adaptation would have been equally effected by both central and peripheral masking.

In an investigation into practice effects occurring in visual masking paradigms, Wolford, Marchak and Hughes (1988) found that much larger practice effects occur in a backward masking paradigm where patterned masks were used, than lateral masking, whole report technique, letter detection or brightness masking. Four possible explanations were considered for these large practice effects - increased familiarity with the paradigm in general, learning about the targets, learning about the masks and enhanced sensory processing. These factors were systematically evaluated in a series of four experiments. They found that practice effects were due to learning about the specific features of the mask and enhanced central sensory processing. Factors which may have facilitated enhanced sensory processing included increased alertness and vigilance on the part of the subject and increased speed of processing. Wolford, Marchak and Hughes (1988) postulated that increased speed of processing may have involved a criterion shift in that subjects, with experience, may be prepared to make a decision using less of the presented material. This would suggest a strategy change.

Practice effects have been noted in both retarded and non-retarded subjects (Nettelbeck, Evans & Kirby, 1982) with both groups improving in discriminative performance at about the same rate (non-retarded - 30 per cent; retarded - 24 per cent).

Nettelbeck (1987) acknowledged that I.T. shows some sensitivity to initial practice and advised that more time be spent familiarising the subjects to the task. He notes that evidence on practice effects in I.T. tasks is available from eight studies (Nettelbeck, 1987, Table 4). Of these eight studies only two recorded no improvement. Amongst those studies which did show improvement in I.T. measures after practice was a study by Irwin (1984, Expt. 2) in which 12 year old subjects showed a 34 percent reduction in I.T. and a study by Mackenzie and Bingham (1985) in which university students showed a 31 percent improvement in I.T. Nettelbeck (1987) considered that the large improvements in these two studies were due to the difficulty of the particular I.T. task used in each experimental procedure.

During a pilot study, Mackenzie and Bingham (1985) had noted that when the stimuli were presented in a fixed position, some subjects developed a strategy of focussing attention only on that small part of the screen where the length of the longer line would appear. They therefore introduced a random shift from trial to trial in the horizontal position of the common starting point on the left of both lines to prevent this strategy. Nettelbeck (1987) considered that this would increase the difficulty of the task and thus require more than one inspection to make a decision. Alexander and Mackenzie (1987) comparing mean I.T. thresholds with a moving (M) and still (S) target found that moving the stimulus position did not require additional fixation time nor presumably, more inspections. Thus, the perceived difficulty of a moving target would not appear to be an explanation for practice effects noted in the Mackenzie and Bingham (1985) experiment.

1.4.2 Strategies

It is generally acknowledged (Brand, 1984; Nettelbeck, Evans & Kirby, 1982; Nettelbeck, 1987) that in all I.T. measures there are some subjects for whom the masking procedure fails. Or putting it another way, some subjects "are able to use subtle post masking cues such as apparent motion and changes in levels of brightness to overcome the effects of the mask". In so doing they achieve unusually high levels of accuracy at very brief target durations. The effect of widespread use of this apparent motion strategy markedly reduces the I.T.-I.Q. correlation (Mackenzie & Bingham, 1985; Mackenzie & Cumming, 1986). It also confounds the effectiveness of Inspection Time as a valid noncognitive index of ability.

Brebner and Cooper (1986) have suggested that use or non use of an apparent motion strategy may in part be due to individual differences in personality. They found a three way interaction between a personality variable, strategy use and condition; the extraverted strategy users had significantly faster I.T.s than other subjects under the condition requiring less sustained attention prior to target onset.

In the course of investigating the influence of apparent motion on the measurement of Inspection Time, Mackenzie and his colleagues have noted that subjects report using other mask related strategies (Mackenzie & Cumming, 1986). Alexander and Mackenzie (1987) found that in addition to apparent motion strategies there were others reported which they named Flash/Brightness, Ends-standout, and After-image. The difference in reported frequency of usage of these strategies was significant ($F(4,188)=23.4$, $p<.001$). The non-use of a strategy (Saw-Lines) was significantly higher than the other four strategies ($p<.01$) and Apparent Motion significantly higher than Flash/Brightness ($p<.05$), Ends-standout ($p<.01$) and After-image ($p<.01$). However, the interaction between intelligence and strategy use was not significant ($F(8,188)=1.8$, $p=.08$). They concluded that for subjects who report using an apparent motion strategy, the I.T. threshold measures an individual difference in some characteristic of the visual system, which has little relationship with measured intelligence.

Ward and Ross (1977), presented the notion that the so-called practice effect observed in backward masking paradigms may in fact represent the development of strategies for more efficient filtering, such as enhancing certain critical T.S. features or attenuating M.S. features. That is, to distinguish between the relevant and irrelevant attributes of the T.S.-M.S. condition. Findings by Wolford, Marchak and Hughes (1988) would support the concept that the use of strategies form a basis for observed practice effects.

1.4.3 Apparent motion

Over the past seven years, Mackenzie and his colleagues have been investigating the incidence and influence of apparent motion on the I.T. task. They have found that approximately half the subjects in their Inspection Time experiments report perceiving apparent motion in the stimulus display. That is they see the target lines apparently move or stretch to the length of the longer, overlaying masking lines. They report that the speed of the apparent motion from the end of the long target line to the end of the mask line appears to be different from the speed of apparent motion from the end of the short target line. They apparently use this perceived speed difference to aid them in decision making. The remaining subjects do not report anything like apparent motion. In a recent paper (Mackenzie et al, 1989) five experiments are presented in which the distinction between users and non users of an apparent motion strategy is shown to be a generalised effect across adults, and children and for stimuli other than the original two line target. In any sample some subjects will be users and some non users. The differences in I.T. measure between the two groups are stable with the cue users having slightly shorter I.T.s.

Mackenzie and Bingham (1985) measured I.T. among a sample of 29 university students (W.A.I.S. mean I.Q.=116.2, S.D.=8.4) on a fully computerised task. They ascertained by self report which subjects spontaneously used an apparent motion strategy and then attempted to train the non-users. It was found that the strategy could not be taught readily in a short time. The use or non-use of this strategy was independent of measured intelligence. As predicted the mean I.T. for strategy users (n=16) was significantly lower than for non-users (n=13). There was no significant I.T.-I.Q. correlation for strategy users, whereas among the non-users, I.T. was highly correlated with W.A.I.S. Performance I.Q. (r=-.72) and especially with subtest scores on Block Design (r=-.76) and Object Assembly (r=-.75).

Subsequently, this finding was confirmed by Mackenzie and Cumming (1986) and Doyle (1986). With a similar sample of mostly university students, Mackenzie and Cumming (1986) found a high correlation between I.T. and scores on the Advanced Progressive Matrices for their 15 cue non-users (r=-.66) and a nonsignificant correlation (r=-.19) for cue-users (n=22). Doyle (1986) using a similar computerised procedure investigated the effect with a normal 12 year old sample to find that the I.T. of cue non-users (n=22) correlated significantly with Full Scale, Verbal and Performance I.Q. on the W.I.S.C.-R (r=-.66, -.65, and -.60, respectively) whereas the correlations for cue users (n=16) were again not significant.

Turner (1986) attempted to overcome the effect of apparent motion by using an inspection time stimulus which did not stretch out in any one direction and thus would not afford an opportunity for seeing apparent motion. The stimuli were either a diamond or a square and a combination of the two as a mask. The technique of forming a mask from two targets was first used in inspection time research by Longstreth, Walsh, Alcorn, Szeszulski and Manis (1986) and makes the discrimination more of a temporal order judgement than a shape or length discrimination. The student sample was divided into cue-users and non-users on the basis of their response to a standard two-line I.T. task. I.T.-I.Q. correlation was then assessed between a composite score on Standard Progressive Matrices and Advanced Progressive Matrices and the I.T. measure on the square/diamond T.S.-M.S. combination. The I.T.-I.Q. correlation was -.66 in non perceivers and -.02 in perceivers. Of equal interest was the significant relationship between seeing apparent motion in the two line task and apparent depth in the square/diamond T.S.-M.S. combination (chi-square $p<.001$). The findings of this study showed that differences between perceivers and non perceivers of apparent motion were replicable with at least some other perceptual phenomena including one form of temporal order judgement.

Finally, Molloy (1988) attempted to build on the results of Turner (1986) by measuring widely accepted perceptual mechanisms (sensitivity of transient and sustained systems in visual perception) and testing for differences in these mechanisms between perceivers and non perceivers of apparent motion. The study showed there were significant differences between perceivers and non perceivers in contrast sensitivity. The perceivers displayed higher sensitivity at both fast and slow flicker rates, with the difference slightly greater at the slow flicker rate. Thus, perceptual mechanisms seem to be clearly implicated in the differences between perceivers and non perceivers, but it is not yet clear as to the basis or mechanism of this perceptual difference. The I.T.-I.Q. correlation between non perceivers and I.Q. (SPM) was -.42, with a low -.01 for perceivers.

Whilst apparent motion provides an interesting problem to solve, at the moment it confounds the I.T.-I.Q. research and this is an even greater problem as Egan (1986) points out. However, he takes a positive stance in suggesting that formal criteria be used for identifying strategies and then these strategies be examined for their impact on I.T. and on I.T.-I.Q. In fact, he suggests that subjects should be fully trained in the use of strategies prior to evaluating strategy impact on I.T. and the I.T.-I.Q. relationship.

1.5 The Present Study

From a review of the literature it would appear that there are a number of mask-related problems which have not been considered by the researchers of Inspection Time.

The extent and nature of strategy use, the incidence of practice effects, the effectiveness of different masks to block post-masking cues and the effect of different masks on the I.T. measure and the I.T.-I.Q. correlation will be addressed in this study.

Since the initial finding by Mackenzie and Bingham (1985) the differences in I.T. measurement and I.T.-I.Q. correlation between perceivers and non perceivers of apparent motion have been replicated using adult and child subjects and for stimuli other than the original two line target stimuli.

The present study aims to develop and test the reliability and effectiveness of different masks in controlling post masking cues and in particular the perception of apparent motion in a standard horizontal two line I.T. task.

Three different masks will be used to attempt to control for the perception of apparent motion. Once apparent motion is controlled, measures will be taken for inspection time, and the correlation between inspection time and measured intelligence will be evaluated.

Studies by Mackenzie and his colleagues have noted that strategies other than apparent motion have been reported by subjects and that there is a significant difference in their reported usage. This study aims to evaluate the spontaneous use of different strategies in different T.S.-M.S. conditions and to investigate the effect of strategy use on the I.T. measurement and I.T.-I.Q. correlation in these different T.S.-M.S. conditions.

It has been suggested by researchers of the backward masking paradigm (Ward & Ross, 1977; Wolford et al, 1988) that specific strategies may be developed to overcome specific difficulties in particular T.S.-M.S. combinations. This study plans to evaluate whether the apparent motion strategy and other strategies are specific to the standard two-line I.T. task or whether they are generalised to other T.S.-M.S. conditions.

Finally, the incidence of practice effects will be evaluated using a repeated measures design. Measurement of I.T. using a standard horizontal two line task will be performed at the beginning and at the end of the experimental procedure. Three inspection time measures will be taken on each occasion and the means of these measures will be compared. In addition, the measures comprising each mean I.T. measure, will be evaluated so that not only the incidence of practice effects are evaluated but also the onset and duration of such effects will be considered. Three pattern mask conditions will be interspersed between the two presentations of the standard horizontal two line T.S.-M.S. condition.

Wolford, Marchak and Hughes (1988) found that the highest incidence of practice effects occurred in a backward masking paradigm using patterned masks. They found that both acquisition of knowledge of features of the masking stimulus and enhanced sensory processing which they speculated was due to improved alertness, accounted for practice effects. By presenting the patterned masks in a counterbalanced design it is hoped to differentiate between these two findings. If practice effects are due to enhanced sensory processing one would expect that the mean I.T. of the T.S.-M.S. patterned mask which is presented last would be shorter than those presented in first or second position. Therefore, there would be an order effect wherein each T.S.-M.S. combination will be done better if it comes last in the series rather than first. If practice effects are due to acquiring specific knowledge about the patterned mask then practice effects should appear across the series of three measurements within each pattern mask condition.

In addition to evaluating these aspects of practice, it is planned to evaluate whether use of particular strategies influence the incidence or extent of practice effects in the standard horizontal two line T.S.-M.S. condition and in the patterned mask conditions.

Chapter 2

Method

2. Method

2.1 Subjects

Sixty seven subjects comprised the total sample. There were forty-three (43) undergraduate students in the first year psychology course (1989) at the University of Tasmania and twenty-four (24) persons who answered an advertisement for subjects at the Commonwealth Employment Service (CES) Hobart, Tasmania. Seven (7) subjects were deleted from the total sample prior to data analysis - three (3) subjects failed to finish the I.T. task; two (2) subjects had medical problems which compromised reliability in data collection; two (2) subjects were unable to comply with the I.T. task instructions.

Of the remaining sixty subjects, there were forty-five (45) females and fifteen (15) males. They ranged in age from 18 to 29 years with a median of 19 years and a mean of 20.8 years. All subjects were normal or corrected to normal in visual acuity. None were familiar with the Inspection Time task nor the intelligence test. They were paid $4-00 for each session in which they participated individually.

2.2 Stimulus Materials

2.2.1 Intelligence Test

The Standard Progressive Matrices test (Raven, 1938) was used as the measure of intellectual level. It was administered and scored in accordance with the standardised procedures set out the The Manual for Standard Progressive Matrices (ACER, 1966).

2.2.2 Inspection Time Test

The Inspection Time programme was run on an Apple II+ microcomputer controlled by a PDPII. Stimuli were displayed on an Ingersoll video monitor with a 30cm high resolution monochrome green screen. The decay function of the screen was 5% of original target luminance remaining after 3 msec. The programme was run in a dimly lit room with no natural lighting. The reflected light due to room lighting was held constant at 2.0 cd/m^2. At regular intervals the target and screen luminances were checked with a photometer (positioned 1 metre directly in front of the screen) in order to maintain the level of 5.0 cd/m^2 for T.S. and 0.8 cd/m^2 for screen luminance. Thus the contrast between target and background luminance was 0.72.

Target stimuli were two horizontal parallel lines measuring 55 and 80 mm long with a vertical separation of 24 mm. The standard mask was composed of two horizontal lines measuring 140 mm which covered the target lines. The location of the stimuli on the screen was constant over trials with the difference between the length of the target stimuli lines always appearing to the right of the screen. The width of T.S. and standard M.S. lines was 0.75 mm.

2.2.3 Masks

Four (4) masks of different configuration were used during the I.T. testing procedure. All masks were positioned to completely cover and extend beyond the target stimulus lines.

(i) Standard 2 line mask was composed of two horizontal lines of same thickness as stimulus lines.

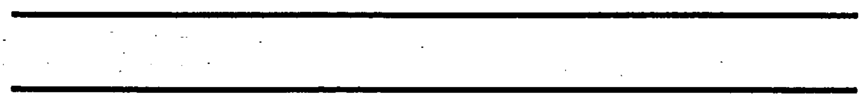
(ii) The chequer-board mask - comprised two horizontal lines composed of computer derived "delete" character and "hyphen" character single spaced alternately across the screen.

(iii) The dynamic mask first used by Doyle and Leach (1988) was made up of four successive distinct pattern masking fields each composed of 2 lines of non-alphanumeric characters. The sequence of characters changed randomly every 40 seconds for the first 3 presentations with the last sequence of characters remaining on the screen until the subject responded.

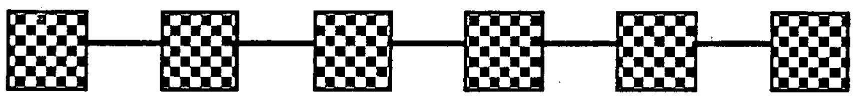
(iv) The hatch mask comprised 2 horizontal lines of single spaced computer derived "hatch" characters (###) extending across the screen.

The height of each lines of the standard 2 line mask was approximately 0.75 mm, whereas the height of each line of the patterned masks was 5.8 mm.

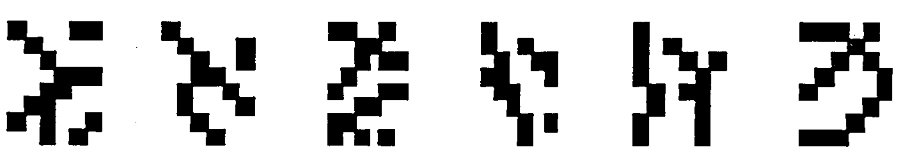
(1)



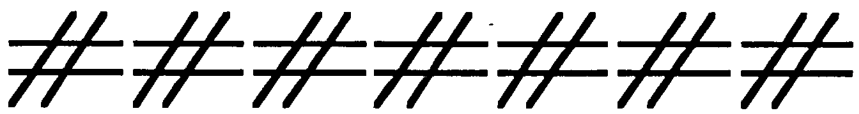
(2)



(3)



(4)



The chequer-board mask and the hatch mask were not derived from rigorous theory but rather by testing the blocking effect of a variety of static masks which had been derived by using different characters generated by the computer programme. The main considerations in designing these masks were that the contours of the mask (M.S.) completely covered the target (T.S.) and that the details of the mask overlapped and broke up the unity of the T.S. (Kahneman, 1968) thus minimizing the subject's percept of an integrated target-mask; minimizing temporal summation and eliminating visible persistence of the target.

The decision to use the dynamic mask developed by Doyle and Leach (1988) was purely pragmatic. As a M.S. it disrupted the features of the T.S. by what appeared to be a combination of it totally overlapping the T.S. and a rapid oscillatory type movement which occurred within the confines of the M.S. every time the field changed.

The standard two line mask was used in the first and final blocks of I.T. trials. The patterned masks were presented, using a counterbalanced design, in blocks two to four inclusive.

Chapter 3

Procedure

3. Procedure

3.1 Intelligence Test

The undergraduate students had the Standard Progressive Matrices (SPM) test administered to them as a group during the 1989 Psychology I course at University of Tasmania.

The SPM test was administered individually to other subjects after each one had completed the I.T. task.

3.2 Inspection Time

Subjects were tested individually. Each subject completed Inspection Time trials under five target-mask (T.S.-M.S.) conditions. Within each condition there were three separate blocks of trials.

The exposure duration of the target stimulus (T.S.) was controlled by the adaptive staircase procedure of Wetherill and Levitt (1965). The exposure duration for each trial is set by this procedure which increases the exposure duration one step after an incorrect response, and decreases the exposure duration one step following a criterion number of correct responses. The criterion number of consecutive responses, the step size and the number of permissible reversals were under programme control. The trial onset was always synchronised with the beginning of the computer monitor's raster refresh cycle, to enable exact timing of exposure duration.

Each block of trials had two staircase procedures - the second following the first without a break. The first staircase was used to establish a preliminary threshold estimate of Inspection Time and from this the initial exposure duration for the start of the second staircase was determined. The calculation of the Inspection Time measure for each block was made entirely on the basis of results on the second staircase.

For the first staircase the initial exposure duration was 400msec, the stepsize was 100msec, the criterion number of consecutive responses for a 'reversal' on the staircase was 3 and total number of reversals was 4. In the second staircase the initial exposure duration was determined by the performance level attained in the first staircase. Following the 'stepwise' procedure as outlined above an accuracy level of 79.4 per cent was calculated. In order to attain this level of accuracy, the criterion level was set at 3, the stepsize was 20msec and 8 reversals were programmed.

As with previous Inspection Time studies performed at the University of Tasmania (Bingham, 1983; Cumming, 1984; Ridgers, 1986; Lancaster, 1986) the actual level of correct responding was used as the measure of Inspection Time. This was used in preference to the derived estimate of Inspection Time which involves an extrapolation to the 97.5 per cent level as frequently reported by Nettelbeck (Nettelbeck, 1987).

Subjects were seated approximately 75 cm from the video screen so that the shorter and longer lines of the T.S. would subtend focal angles of 3.1° and 4.6° respectively. Subjects were required to identify the longer of the two horizontal lines making up the T.S. after they had been covered by the M.S. Responses were recorded by pressing one of two response buttons mounted on a rectangular panel. The panel was held vertically so that the top button indicated the top line, and the lower button, the bottom line. Subjects pressed whichever button corresponded to the longer line of the T.S.

The time needed by subjects to complete blocks of trials for the five T.S.-M.S. conditions varied between 45 - 60 minutes depending on response latency and overall consistency in responding. While the number of reversals remained constant across conditions the number of individual trials within a block was not controlled by this procedure.

Prior to the commencement of the measurement of Inspection Time, the task requirements were fully explained and demonstrated to the subject. It was emphasized that the vital aspect of this measure was accuracy not speed of responding; that the task would become increasingly difficult and should it become almost impossible to determine which of the target lines was longer, to guess and register this on the response panel.

Prior to the commencement of measurement of I.T. using the first T.S.-M.S. condition, the subject was told that the masking lines were the same as the target lines but they extended across the screen. At the commencement of subsequent T.S.-M.S. conditions, the subject was told whether the masking lines were the same or different from those of the previous conditions. This was done to reduce the surprise element which may have momentarily diverted attention.

Every presentation of the target stimulus (T.S.) was preceded by an "alerting" tone given 1 sec prior to onset of T.S. The T.S. appeared onto the screen, followed rapidly by the backward masking stimulus. Subjects indicated which T.S. line had been longer by pressing the appropriate button on the response panel. There was a 1 sec pause between the response to the stimulus and the alerting tone for the next T.S. presentation. A short rest period (2-3 minutes) was introduced between every T.S.-M.S. condition and subjects were allowed to stand and stretch if they so desired.

There was no overt feedback mechanism used. However, the large step-sizes employed in the preliminary threshold estimate made it obvious that the on-time of the T.S. was increased after every incorrect response and became shorter if responses were correct. All subjects, without exception, commented on this. All responses and Inspection Time calculations were recorded automatically on computer disk.

At the completion of each three-trial block, subjects were asked two questions designed to explore the observance of apparent motion and the use of cognitive strategies in performing the inspection time task. The answers were recorded verbatim on the experimenter's running sheet.

3.3 Questions.

1. What looks to be happening on the screen when the initial two lines are covered extremely quickly by the long covering lines?

2. When the initial two lines are covered extremely quickly by the long covering lines, some subjects seem to try different "tricks" to make it possible to still make a considered decision rather than just guessing. Could you explain to me how you made decisions on the very fast presentations?

Chapter 4

Results

4. Results

Measures of Inspection Time (I.T.) at the 79.4 per cent accuracy level were calculated for all subjects from data collected in each of five (5) mask conditions (Table 1). Details of each subject's scores on all conditions of I.T. measures are given in Appendix A along with details of strategy/non strategy used for each of the five conditions, and the order of presentation of the pattern masks. Means, standard deviations (SD) and range of I.T. measures in msec for all blocks of trials (n=15) at 79.4 percent accuracy level for all subjects are given in Appendix B.

Table 1 - Means, standard deviations (SD) and range of I.T. measures in msec at 79.4% accuracy level for all subjects in the five mask conditions.

	Mean	SD	Range	Reliability
$I.T._{(1)}$	46.90	25.78	15.00-130.00	0.84
$I.T._{(2)}$	57.86	18.30	27.50-123.33	0.80
$I.T._{(3)}$	42.72	19.51	13.33- 93.33	0.87
$I.T._{(4)}$	45.17	22.81	11.67-155.00	0.91
$I.T._{(5)}$	36.88	24.84	10.84-137-50	0.86

$IT_{(1)}$	Mean I.T. Blocks 1, 2 and 3, 1st presentation standard two-line T.S.-M.S. condition
$IT_{(2)}$	Mean I.T. Blocks 1, 2 and 3, Delete-hyphen mask condition
$IT_{(3)}$	Mean I.T. Blocks 1, 2 and 3, Dynamic mask condition
$IT_{(4)}$	Mean I.T. Blocks 1, 2 and 3, Hatch mask condition
$IT_{(5)}$	Mean I.T. Blocks 1, 2 and 3, 2nd presentation standard two-line T.S.-M.S. condition

The reliability of I.T. measures ranged from 0.80 to 0.91 with a mean of 0.87 (Cronbach's A, cited in Ferguson, 1976) which compared favourably with reliabilities presented by Nettelbeck (1987, Table 4).

All mean I.T. measures ($I.T._{(1)-(5)}$) were subjected to a multivariate analysis of variance (MANOVA) for repeated measures. The main effect of mask type was significant $F(4,236)=20.22$, $p=0.0000$.

Subsequent comparison among means by dependent group t-tests shows that the mean I.T. of the last presented T.S.-M.S. condition, that is, second presentation of the standard two line T.S.-M.S. condition ($I.T._{(5)}$) was significantly shorter than all other I.T. measures. The mean I.T. achieved with the delete-hyphen mask ($I.T._{(2)}$) was significantly longer than all other mean I.T. measures (Table 2).

Table 2 - Comparisons between all I.T. measures given as dependent t-test scores.

	$I.T._{(1)}$	$I.T._{(2)}$	$I.T._{(3)}$	$I.T._{(4)}$	$I.T._{(5)}$
$I.T._{(1)}$					
$I.T._{(2)}$	3.9***				
$I.T._{(3)}$	1.4	8.2***			
$I.T._{(4)}$	0.6	5.8***	1.4		
$I.T._{(5)}$	6.1***	7.4***	2.2*	3.5***	

* p<.05
** p<.01
*** p<.001

With $I.T._{(2)}$ being significantly longer than other mean I.T. measures, it would appear that the 'delete-hyphen' mask (with a reliability of 0.80) most effectively masked the target stimulus.

The $I.T._{(5)}$ measure was significantly shorter than all other I.T. measures (p<.05). As this was the final I.T. measurement taken, it would appear that this result indicates that a major practice effect occurred between the first and last measurements of I.T. both using the standard 2 line target-mask condition.

4.1 Inspection Time and Measured Intelligence

Mean I.Q. on the S.P.M. for the total sample was 116.6 with a standard deviation of 10.17. The range was 93-130. The correlations between the five I.T. measures and S.P.M. for the total sample are shown in Table 3 and are non significant for all I.T. measures.

Table 3 - Correlations between I.T. measures and S.P.M.

	$I.T._{(1)}$	$I.T._{(2)}$	$I.T._{(3)}$	$I.T._{(4)}$	$I.T._{(5)}$
I.Q.	-0.14	-0.25	-0.23	-0.07	-0.20

Whilst these I.T.-I.Q. correlations fall in the lower end of the spectrum of I.T.-I.Q. correlations in an I.T. paradigm they are not unique for I.T.-I.Q. correlations using a young adult population and S.P.M. as the I.Q. measure (Nettelbeck & Kirby, 1983). Although the mean I.Q. for this sample is 116.6, the distribution is markedly skewed towards the upper levels of I.Q. with 26 of the 60 cases having SPM scores in the range 52-55 (I.Q. 126-130) It may well have been more appropriate to have used the Advanced Progressive Matrices to avoid "ceiling effects". However, Irwin (1984 Expt. 3) using A.P.M. with a similar demographic sample mean I.Q.=120, S.D.=8, established an I.T.-I.Q. relationship of -0.17. Therefore, upgrading the I.Q. measure to avoid ceiling effects may not be the answer.

Unfortunately the reliability with which the S.P.M. was conducted cannot be established. The university students were given the S.P.M. in a group presentation by numerous tutors and the individual presentations to other subjects were also given by three different persons. This procedural deficiency may well have introduced unexplained variability.

4.2 Strategy use

On reviewing the data provided by subjects on how they performed the various I.T. tasks, it became clear that there were two significantly different strategies used or no strategy use at all. Users of the Apparent Motion strategy typically described their technique as - "watching the speed of the covering lines"; "the covering line of the longer T.S. line always finishes first"; "I look for the last finishing line and then register the other". These statements are in accordance with those reported in previous studies (Mackenzie & Bingham, 1985; Mackenzie & Cumming, 1986; Alexander & Mackenzie, 1987).

The other strategy was named the End-Point strategy. Subjects using this strategy either made no mention of movement in the T.S.-M.S. complex or made mention of movement but clearly stated they did not use that as a decision strategy. They all made comment to the effect that they were fixating gaze at the ends of the T.S. lines or making an angular comparison of the end points of lines: . ˙ or ˙ .. Some stated that they estimated where the long line would end for one line (either upper or lower) and if they gazed at that point and saw the end of the line they would know it was the longer one, if not, they would assume that the other line had been longer and register accordingly. This strategy appears to involve a shift in the criterion used by subjects to make a decision viz looking at only part of the T.S.

The remainder of subjects reported just seeing the lines - no mention of movement, "tricks",or change in decision criterion just looked very carefully at the T.S. lines; concentrated very hard and tried to overcome the effect of the masking stimulus.

On completion of every T.S.-M.S. condition subjects were asked the two probe questions. According to their response, they were categorised apparent motion users, end point strategy users or no strategy used for that T.S.-M.S. condition. Whilst some subjects were consistent in their response strategy use, others varied their response strategy over different T.S.-M.S. conditions. The response strategy data was subjected to a separate one way analysis of variance for each T.S.-M.S. condition, thus five separate ANOVAs.

There was no evidence of significant differences in mean I.T. due to response strategy in I.T.$_{(1)}$, I.T.$_{(2)}$, I.T.$_{(3)}$ or I.T.$_{(4)}$. The only significant effect was found in I.T.$_{(5)}$ (second presentation of the standard T.S.-M.S.) measure. In I.T.$_{(5)}$ the End point strategy users achieved the shortest mean I.T. ($F(2,57)=3.80$, $p=.03$).

The full results of I.T. measures across different mask conditions with subjects using different strategies is in Appendix B.

Results of a one way analysis of variance between I.Q. and which strategy/non strategy was used on each of the five I.T. measures showed there was no significant difference in I.Q. between the three groups on any of the five I.T. measures. Analysis of the I.T.-I.Q. correlation, when both strategy use/non use and mask type was taken into consideration, revealed that the only significant correlation occurred in the I.T.$_{(2)}$ measure with the delete-hyphen mask.

In this condition mean I.T. of End-Point strategy users (n=18) correlated with I.Q. significantly r=-0.51, p=.05. Of the three groups, the End-Point strategy users had the highest mean I.Q. (117.81, S.D.=10.13) and the shortest mean I.T.=54.40 msec (S.D.=15.00 msec). The reliability of this measure was 0.81. Full details of I.T.-I.Q. correlations for all groups in all mask conditions are given in Appendix C.

The number of subjects using/not using strategies varied across the five I.T. measurements.

Table 4 - Subject numbers use/non use strategy across different I.T. tasks.

(%)		AMS (%)	EPS (%)	NS (%)
I.T.$_{(1)}$	standard two-line mask (1st presentation)	29 (48)	21 (35)	10 (17)
I.T.$_{(2)}$	delete-hyphen mask	11 (18)	18 (30)	31 (52)
I.T.$_{(3)}$	dynamic mask	8 (13)	21 (35)	31 (52)
I.T.$_{(4)}$	hatch mask	12 (20)	19 (32)	29 (48)
I.T.$_{(5)}$	standard two-line mask (2nd presentation)	19 (32)	27 (45)	14 (23)

AMS = Apparent Motion Strategy
EPS = End-Point Strategy
NS = No strategy used

The apparent motion strategy was used by 48 per cent of subjects on the first presentation of the standard two line T.S.-M.S. condition whereas the numbers dropped to 32 per cent usage on the second presentation of the standard two-line T.S.-M.S. condition. During the measures taken when pattern masks were in use (viz. $I.T._{(2)}$ delete-hyphen; $I.T._{(3)}$ dynamic; and $I.T._{(4)}$ hatch) only 13 - 20 per cent of subjects reported using apparent motion as a strategy (Table 4). The End-Point strategy was used consistently across all conditions by 30 - 45 per cent of subjects (Table 4) with the highest rate (45 per cent) occurring during presentation of the last T.S.-M.S. condition $I.T._{(5)}$ (second presentation of the standard two line T.S.-M.S. condition). Whereas 77 - 83 per cent of subjects reported using a strategy during the standard two line T.S.-M.S. condition, only 48-52 per cent of subjects reported using a strategy during the three pattern T.S.-M.S. conditions.

The finding that reportage of strategy use is significantly/markedly reduced during the T.S.-M.S. conditions where a patterned mask is used ($I.T._{(2)}$, $I.T._{(3)}$, $I.T._{(4)}$), along with the finding that there was no significant difference in mean I.T. for strategy users/non users in these conditions, would suggest that patterned masks go some way to control the effects of visuoperceptual strategies (Apparent Motion strategy) and criterion shift strategies (End Point strategy).

Of the two strategies the apparent motion strategy was the more effectively controlled by the patterned masks. Of the 29 subjects who used this strategy during the first presentation of the standard two line T.S.-M.S. condition ($I.T._{(1)}$), only 11 used it for the delete-hyphen mask ($I.T._{(2)}$). The number of subjects (n=19) using apparent motion for the second presentation of the standard two-line T.S.-M.S. condition, although not reaching initial numbers, climbed considerably from the low numbers during the pattern masks. It would appear that this visuoperceptual strategy is T.S.-M.S. specific and can be controlled by using patterned masks.

4.3 Practice effects

Overall there was a significant reduction in mean I.T. on the standard two-line T.S.-M.S. condition from its first measure ($I.T._{(1)}$) to its second measure ($I.T._{(5)}$) taken in the last block of trials, $t(59)=6.1$, $p<.001$, two-tailed. This would suggest a significant practice effect.

To determine where practice effects occurred during the course of the experimental procedure, a within subject analysis of variance was performed on each three I.T. measures used to determine each of the five mean I.T. measurements ($I.T._{(1)}$, $I.T._{(2)}$, $I.T._{(3)}$, $I.T._{(4)}$, $I.T._{(5)}$). Results showed that practice effects occurred within the first three blocks of trials comprising $I.T._{(1)}$ $F(2,118)=9.53$, $p=.0003$, and between the third block of trials of $I.T._{(1)}$ and the first block of trials of $I.T._{(5)}$, $t(59)=3.20$, $p<.01$. Although mean $I.T._{(5)}$, and the three measures comprising $I.T._{(5)}$ were all significantly shorter than mean $I.T._{(1)}$, there were no significant practice effects between the three I.T. measures comprising mean $I.T._{(5)}$. See Appendix B.

There were no practice effects between the three measures comprising each mean of $I.T._{(2)}$, $I.T._{(3)}$ and $I.T._{(4)}$. See Appendix C. Neither were there any practice effects across the presentation of these three pattern mask conditions ($I.T._{(2)}$ delete-hyphen; $I.T._{(3)}$ dynamic; $I.T._{(4)}$ hatch). These mask conditions were presented in a counterbalanced design between the first and second presentations of the standard two-line T.S.-M.S. condition. Results of three separate one-way analyses of variance showed that for each pattern mask condition there was no significant difference in mean I.T. due to position of presentation (viz 1st, 2nd or 3rd) ($F<1.0$, n.s.).

It was impossible to determine if subjects using particular strategies contributed more to the overall reduction between mean $I.T._{(1)}$ and mean $I.T._{(5)}$ as numbers for each group differed from $I.T._{(1)}$ to $I.T._{(5)}$ (Table 5). However, for the forty-five (45) subjects who reported using the same approach during both measures it was possible to evaluate the effect of particular strategies..

Apparent motion users in $I.T._{(1)}$ and $I.T._{(5)}$ = 19

$I.T._{(1)}$ - $I.T._{(2)}$ $t(18)=-2.95$, $p=.01$

End point strategy users in $I.T._{(1)}$ and $I.T._{(5)}$ = 20

$I.T._{(1)}$ - $I.T._{(2)}$ $t(19)=-4.14$, $p=.001$

No strategy use in $I.T._{(1)}$ and $I.T._{(5)}$ = 9

$I.T._{(1)}$ - $I.T._{(2)}$ $t(8)=-2.75$, $p=.05$

In summary, these results would suggest that significant practice effects occur early in the inspection time procedure with the standard two line T.S.-M.S. condition and are universal across different strategy approaches. However practice effects do not occur within or across I.T. measures where patterned masks are used as the masking stimulus. Despite lack of practice effects during the intervening measures when patterned masks are used, there is significant enhancement in performance between the first mean $I.T._{(1)}$ and the last mean $I.T._{(5)}$ both using the standard two-line mask.

Chapter 5

Discussion

5. Discussion

The main purpose of this study was to evaluate a number of procedural problems in the Inspection Time research which had not previously been evaluated. These problems appeared to be related to the backward masking stimuli and procedure used in the measurement of Inspection Time. In the course of the study three new masks were generated and evaluated for efficiency and reliability in controlling post masking cues. The effect of these different masks on the mean I.T. measure and on the I.T.-I.Q. correlation was assessed. The occurrence and nature of strategy use across different T.S.-M.S. conditions was examined, classified and clearly documented. Finally, by using a repeated measures design it was possible to determine the extent and nature of practice effects. All these procedural problems are found to be closely interrelated. However, for clarity, the findings pertaining to each problem will be discussed in turn.

5.1 Influence of Different Masks

Results of this study showed clearly that within a single experimental procedure conducted over less than one hour and under strict experimental conditions, mean I.T. measure was significantly influenced by the use of different masking stimuli.

The mean I.T.$_{(2)}$ using the delete-hyphen mask was significantly longer than other mean I.T. measures using either the standard two line mask, dynamic mask or hatch mask. The mean I.T. measures with the dynamic and hatch masks showed no significant difference from each other, nor from the first mean I.T. using the standard two-line T.S.-M.S. mask. Finally, the mean $I.T._{(5)}$ measure using the standard two-line T.S.-M.S. mask had the shortest mean I.T.

The longest mean I.T., with the delete-hyphen mask ($I.T._{(2)}$), appeared to be due entirely to characteristics of the mask rather than order or practice effects. The shortness of the mean $I.T._{(5)}$ seemed to be due to a combination of practice effects and the characteristics of the mask.

Over the entire experimental procedure, 15 different I.T. measurements in 5 conditions were made for each subject. Each mean I.T. was the mean of the 3 I.T. measurements in the same condition with a particular mask. Reliabilities across these mean I.T.s ranged from 0.80 to 0.91 indicating that the experimental procedure, with each mask resulting in quantitatively different mean I.T.s, achieved an acceptable level of reliability.

Of all the masks used, the patterned masks would appear to provide more effective masking features. They were all more effective than the standard two-line mask in controlling the usage of apparent motion as a strategy. Furthermore, they were all resistant to practice effects both within and across separate pattern masking conditions.

Of the three pattern masks, the delete-hyphen mask was clearly superior in effectively masking the T.S. As this is the first time this mask has been used, further research using this mask alone will be required to establish its reliability across more than three repeated measures.

The results also indicate that the standard two-line T.S.-M.S. condition allows a high level of strategy use. Whether this be visuoperceptive or shift in decision criteria, both strategies attempt to reduce the cognitive load of the task. This mask is also very susceptible to the effects of practice across the experimental procedure and within all the strategy/non strategy user categories.

The major implication of these findings is that not all masks are equally effective in masking the T.S. in an Inspection Time procedure. This would appear to place doubt on the validity of comparing results across I.T. studies which use different masking stimuli and perhaps placing doubt on the reliability of the measure itself. The findings also offer some clues as to why there are large differences in the I.T. measures across different studies. It is possible that the cognitive requirements for various I.T. tasks may be different, despite apparent similarities in procedure.

5.2 Strategy use

This study replicated findings reported by Mackenzie and Cumming (1986) and Alexander and Mackenzie (1988) that, in addition to the apparent motion strategy, there are other response strategies developed spontaneously by subjects in order to make the I.T. task easier.

This study clearly documented the description and reported usage of two widely used and intrinsically different strategies, that is, Apparent Motion strategy (AMS) and End-point strategy (EPS). Whilst the use of apparent motion as a strategy is dependent on the subject's ability to perceive this phenomenon, the use of the End-point strategy appears to be based on a conscious decision by the subject to use only that part of the T.S. which appears essential to the decision making process. As subjects became more familiar with task requirements they appeared more confident about reducing the decision criteria. Twenty one (21) subjects used End-point strategy (EPS) during $I.T._{(1)}$ (first presentation standard two-line T.S.-M.S. condition) measures but by $I.T._{(5)}$ (second presentation of the standard two-line T.S.-M.S. condition), twenty seven (27) subjects chose to use this approach. The EPS was more consistently used across all masking conditions than the AMS which appeared to be task specific for the two-line standard T.S.-M.S. condition. All these findings on strategy use are in line with those of Ward and Ross (1977) and Wolford, Marchak and Hughes (1988).

The high incidence of reported usage of either strategy during the standard two-line T.S.-M.S. conditions (77-83 percent) was reduced to 48-50 percent during the pattern mask conditions. This reduction was mainly due to the reduction to 13-20 percent reported usage of apparent motion strategy.

Although strategies were spontaneously and clearly reported there was no evidence of significant difference in mean I.T. due to response strategy in the first presentation of the standard two line T.S.-M.S. condition, nor in I.T. measures using pattern masks. The only significant result due to response strategy was with End Point strategy users during the second presentation of the standard two line T.S.-M.S. condition. Unfortunately, this measure had a reliability of only 0.48 across the three measures comprising the score and thus must be questionable. Previous studies by Mackenzie and his colleagues have shown that Apparent Motion users are usually a little faster on the Inspection Time task than non-users of this strategy but the difference has rarely been significant. In this study the End-point strategy users achieved marginally shorter mean I.T. measures across most T.S.-M.S. conditions than either the Apparent Motion users or strategy non users. Despite the low reliability of the I.T.$_{(5)}$ measure for End-point strategy users (n=27), it is a significant result and taken with the finding that EPS users had marginally faster I.T.'s on most I.T. measures, suggests that this is an effective strategy for reducing the Inspection Time whereas the Apparent Motion strategy did not lead to such reductions. The EPS finding warrants further evaluation especially as it has been shown in this study that the use of this strategy increases with familiarity with the task and practice of the skill and is consistent across all T.S.-M.S. conditions.

This study failed in its attempt to evaluate the I.T.-I.Q. correlation when strategy use/non use was considered. This would appear to be due to the highly skewed distribution of I.Q.'s in the sample. However, there was one significant I.T.-I.Q. correlation (r=-0.5) for End-point strategy users in the delete-hyphen mask condition (I.T.$_{(2)}$). In view of the other significant findings and trends to do with End-point strategy use, this strategy would appear to warrant further investigation with a normally distributed I.Q. sample.

5.3 Practice effects

Practice effects were shown to occur between the three measures comprising mean I.T.$_{(1)}$ using a standard two-line T.S.-M.S. condition; between means I.T.$_{(1)}$ and I.T.$_{(5)}$ both using the standard two-line T.S.-M.S. condition; between the third (I.T.$_{(1)3}$) of the measures comprising I.T.$_{(1)}$ and the first (I.T.$_{(5)1}$) of the measures comprising mean I.T.$_{(5)}$, but not between the three measures comprising mean I.T.$_{(5)}$. Nevertheless, the three I.T. measures comprising mean I.T.$_{(5)}$ were all shorter than mean I.T.$_{(1)}$.

However, practice effects did not occur in the I.T. measures using pattern masks (I.T.$_{(2)}$ delete-hyphen; I.T.$_{(3)}$ dynamic; I.T.$_{(4)}$ hatch). Review of the nine separate I.T. measures comprising mean I.T.$_{(2)}$, I.T.$_{(3)}$ and I.T.$_{(4)}$ (Appendix B) show that there is not even a tendency towards a practice effect. Neither were there any order effects across the counterbalanced presentation of the three pattern masks. Although these findings are not in line with the findings of Wolford, Marchak and Hughes (1988), it is possible that the required feature analysis of the pattern masks was greater than that for the standard two-line masks and that no one pattern was presented sufficiently often for practice to occur. Wolford, Marchak and Hughes (1988) would hypothesize that the lack of practice effects was due to the subjects having insufficient time and experience to learn about the specific features of the mask. They would also speculate that the lack of order effects in the presentation of the pattern masks suggested that, again due to insufficient presentations, enhanced sensory functioning had not yet occurred.

Despite absence of practice effects within the measurements of I.T. during the pattern mask conditions, there was a marked improvement over the performance levels from the last measurement of I.T.$_{(1)(3)}$ (first presentation of standard two-line T.S.-M.S. condition) and the first measurement of I.T.$_{(5)(1)}$ (second presentation of standard two-line T.S.-M.S. condition) ($t(59)=3.20$, $p<.01$). This improvement may have been due to practice on the intervening pattern masks or the mere passage of time. One might speculate that this improved performance was due to subjects becoming more quickly aware of the criterion features of the simpler masking configuration of the standard two line mask. Alternatively, the difficulty of the pattern masks, especially the delete-hyphen mask, may have caused subjects to be more consistently alert/vigilant to the T.S.-M.S. task and with the simpler mask, the performance was more readily enhanced. Findings by Wolford, Marchak and Hughes (1988) would suggest that although no practice effects were shown in the pattern mask conditions, they would appear given a greater number of presentations. Further studies using one pattern mask only would be required to determine whether the pattern mask, given regularly over a single experimental procedure, would still be resistant to practice effects. Of the three masks used in this study, the delete-hyphen mask would appear to be the most suitable given its greater effectiveness in masking the T.S.

The fact that subjects' performance with the standard two-line mask improved from the beginning to the end of the experimental procedure is cause for concern about the reliability of the Inspection Time measure. Nettelbeck (1987) acknowledges the presence of practice effects but considers they can be overcome by making subjects more familiar with the experimental procedure before commencing the actual I.T. measurement. The results of this study would not support this belief, in that skill improvements were still evident during the final I.T. measure (I.T.$_{(5)}$), some 45-60 minutes after commencement of the procedure.

Chapter 6

Conclusion

6. Conclusion

This study has clearly shown that practice effects, strategy use and different T.S.-M.S. conditions all affect the measurement of Inspection Time. Practice effects continue to occur across the duration of a full experimental procedure using a standard two-line T.S.-M.S. condition and would appear to be due to strategy use and to the enhancement of perceptual skills. Clearly different T.S.-M.S. combinations have differing effects on the cognitive load or difficulty of the Inspection Time task. Accordingly, in order to evaluate the I.T.-I.Q. correlation it would appear that the measures of both I.T. and I.Q. require further close examination. The mask used in I.T. measurement needs to effectively mask the T.S. and be resistant to strategy use and practice effects. The delete-hyphen mask was clearly superior in this study but further evaluation is required. The I.Q. measure needs to be such that it is appropriate for the sample and can be evaluated via its constituent parts. Furthermore, procedural aspects of the I.T. measure need to be standardised before it is appropriate to make comparisons across different I.T. studies. Once these factors were controlled, the reliability and meaningfulness of the I.T.-I.Q. correlation would be significantly enhanced.

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Appendix A

1. Explanatory codes for raw data.

2. Raw data.

Appendix A

Scores on each Inspection Time measure, strategy used for each Inspection Time measure and order of presentation of the pattern masks for all subjects (n=60).

<u>Code</u>:

Subj	Subject number in order of testing
IQ/SPM	Measured intelligence on Standard Progressive Matrices
$IT_{(1)}$	Mean I.T. Blocks 1, 2 and 3, 1st presentation standard two-line T.S.-M.S. condition
$IT_{(2)}$	Mean I.T. Blocks 1, 2 and 3, Delete-hyphen mask condition
$IT_{(3)}$	Mean I.T. Blocks 1, 2 and 3, Dynamic mask condition
$IT_{(4)}$	Mean I.T. Blocks 1, 2 and 3, Hatch mask condition
$IT_{(5)}$	Mean I.T. Blocks 1, 2 and 3, 2nd presentation standard two-line T.S.-M.S. condition
Strategy	Reported strategy used during each of five I.T. measures apparent motion (3) end point (2) no strategy use (1)
PM Order	Order of presentation of pattern masks delete-hyphen mask (1) dynamic mask (2) hatch mask (3)

Subjno	IQ-SPM	IT1	IT2	IT3	IT4	IT5	Strategy	PMOrder
1	130.00	31.25	50.83	31.67	36.67	31.25	22221	231
2	126.00	33.75	70.00	68.33	64.17	33.75	22222	132
3	111.50	45.00	70.83	47.50	57.50	28.75	22222	312
4	105.00	90.00	85.00	65.83	72.50	73.75	33333	213
5	123.00	18.75	56.67	60.83	53.33	22.50	31111	123
6	128.50	26.25	48.33	13.33	29.17	22.50	22122	321
7	128.50	28.75	41.67	25.83	33.33	27.50	11111	231
8	126.00	28.75	43.33	37.50	32.50	32.50	33333	132
9	126.00	40.00	48.33	25.00	54.17	22.50	33222	312
10	130.00	30.00	50.00	54.17	51.67	27.50	32322	123
11	109.50	36.25	70.83	70.00	39.17	30.00	22222	321
12	111.50	26.25	49.17	24.17	25.83	18.75	33111	231
13	126.00	55.00	44.17	24.17	34.17	21.25	22111	132
14	128.50	58.75	49.17	37.50	25.00	26.25	22212	312
15	128.50	12.50	43.33	27.50	43.33	18.75	22222	213
16	111.50	51.25	43.33	29.17	35.83	23.75	11111	123
17	126.00	30.00	61.67	28.33	45.00	26.25	33311	231
18	111.50	48.75	42.50	35.83	37.50	32.50	22212	132
19	105.00	51.25	80.83	56.67	50.83	20.00	33333	312
20	123.00	28.75	82.50	68.33	45.00	32.50	33111	213
21	116.00	22.50	35.83	23.33	25.83	15.00	11111	123
22	126.00	38.75	45.83	59.17	59.17	38.75	33122	321
23	123.00	38.75	90.83	67.50	83.33	31.25	22121	231
24	123.00	125.00	87.50	93.33	155.00	131.25	11111	132
25	126.00	35.00	49.17	62.50	45.83	22.50	22223	312
26	126.00	38.75	50.83	41.67	33.33	32.50	11111	213
27	123.00	35.00	55.00	45.00	59.17	36.25	33333	123
28	126.00	27.50	57.50	37.50	50.83	33.75	11113	321
29	113.50	27.50	42.50	14.17	24.17	16.25	12111	231
30	130.00	33.75	45.00	23.33	31.67	23.75	22222	132
31	121.00	21.25	43.33	20.00	28.33	12.50	22122	312
32	103.50	78.75	81.67	57.50	67.50	53.75	11111	123
33	118.00	50.00	59.17	35.00	36.67	38.75	33112	321
34	116.00	35.00	45.83	25.83	25.00	32.50	22221	231
35	105.00	42.50	55.00	56.67	50.83	73.75	22222	132
36	107.00	48.75	46.67	25.00	23.33	38.75	22222	312
37	116.00	71.25	58.33	39.17	45.00	47.50	11111	213
38	116.00	25.00	41.67	28.33	29.17	22.50	32222	123
39	107.00	68.75	74.17	71.67	71.67	40.00	33133	321
40	113.50	121.25	123.33	75.83	98.33	60.00	33311	231
41	128.50	52.50	92.50	53.33	60.83	43.75	33131	132
42	116.00	51.25	68.33	45.83	51.67	30.00	33221	312
43	113.50	110.00	60.00	40.00	50.00	123.75	33111	213
44	103.50	40.00	49.17	68.33	49.17	32.50	33313	123
45	130.00	21.25	29.17	20.00	24.17	12.50	33222	321
46	128.50	42.50	67.50	23.33	17.50	12.50	22111	231
47	107.00	33.75	35.83	13.33	36.67	21.25	31111	132
48	94.50	22.50	75.83	45.00	31.67	27.50	21111	312
49	123.00	16.25	27.50	20.83	11.67	10.00	22111	213
50	111.50	36.25	75.00	43.33	33.33	20.00	32113	123

51	101.50	78.75	95.00	92.50	87.50	91.25	33222	321
52	97.50	27.50	61.67	25.83	34.17	41.25	32111	231
53	128.50	32.50	42.50	37.50	30.00	23.75	22111	312
54	109.50	85.00	49.17	48.33	57.50	70.00	11111	213
55	101.50	22.50	56.60	30.83	25.50	13.75	32211	123
56	113.50	18.75	28.33	20.83	15.00	11.25	22133	321
57	113.50	30.00	60.83	50.00	54.17	42.50	31313	213
58	107.00	22.50	61.67	28.33	20.83	28.75	32322	213
59	93.00	35.00	54.17	63.33	49.17	28.75	31111	321
60	103.50	50.00	59.17	58.33	56.67	42.50	33333	132

Appendix B

Means, standard deviations and range of I.T. measures in msec for all blocks of trials.

Appendix B

Means, standard deviations (SD) and range of I.T. measures in msec for all blocks of trials (n=15) at 79.4 percent accuracy level for all subjects.

I.T.	MEAN	S.D.	RANGE
$I.T._{(1)1}$	54.6	36.4	10.0-185.0
$I.T._{(1)2}$	45.8	28.6	15.0-157.6
$I.T._{(1)3}$	40.2	23.0	10.0-110.0
$I.T._{(2)1}$	57.6	19.4	30.0-110.0
$I.T._{(2)2}$	57.8	21.4	22.6-127.6
$I.T._{(2)3}$	58.2	24.6	27.6-175.0
$I.T._{(3)1}$	42.6	22.8	12.6-105.0
$I.T._{(3)2}$	41.4	19.4	10.0- 90.0
$I.T._{(3)3}$	44.2	23.8	10.0-125.0
$I.T._{(4)1}$	44.6	21.6	12.6-110.0
$I.T._{(4)2}$	44.0	24.4	10.0-162.6
$I.T._{(4)3}$	46.8	28.6	10.0-192.6
$I.T._{(5)1}$	33.8	23.0	10.0-132.6
$I.T._{(5)2}$	36.2	26.0	10.0-147.6
$I.T._{(5)3}$	40.6	35.0	10.0-195.0

Appendix C

I.T. means, standard deviations and reliability, I.T.-I.Q. correlations under different mask conditions and strategy use.

Appendix C

I.T. means, S.D.s and reliabilities, I.T.-I.Q. correlations under different mask conditions and strategy use. I.T. means and standard deviations at 79.4 percent accuracy level.

I.T.(1) Standard two line mask (first presentation)

Group	N	IQ Test Mean(SD)	IT Mean(SD)	I.T.-I.Q. Correl^n	I.T. Reliability
Total sample	60	116.60 (10.17)	46.90 (25.78)	-0.13	0.84
AM users	29	114.02 (10.39)	48.40 (28.00)	-0.18	0.91
EP users	21	119.81 (9.79)	40.60 (17.00)	+0.08	0.73
No strategy	10	117.35 (7.82)	55.80 (30.40)	-0.19	0.95

I.T.(2) Delete-hyphen mask.

Group	N	IQ Test Mean(SD)	IT Mean(SD)	I.T.-I.Q. Correl^n	I.T. Reliability
Total sample	60	116.60 (10.17)	57.86 (18.30)	-0.25	0.80
AM users	11	114.18 (9.80)	66.40 (20.00)	-0.31	0.73
EP users	18	117.81 (10.13)	54.40 (15.00)	-0.51 *	0.81
No strategy	31	116.76 (10.18)	56.80 (17.80)	-0.07	0.84

*p<.05

I.T.(4) Hatch mask

Group	N	IQ Test Mean(SD)	IT Mean(SD)	I.T.-I.Q. Correl^{n}	I.T. Reliability
Total sample	60	116.60 (10.17)	45.17 (22.81)	-0.07	0.91
AM users	12	113.63 (8.90)	49.40 (15.60)	-0.32	0.73
EP users	19	119.03 (9.70)	41.80 (17.00)	-0.19	0.93
No strategy	29	116.24 (10.58)	45.60 (27.80)	+0.05	0.93

I.T.(5) Standard two line mask (second presentation).

Group	N	IQ Test Mean(SD)	IT Mean(SD)	I.T.-I.Q. Correl^n	I.T. Reliability
Total sample	60	116.60 (10.17)	36.80 (24.84)	-0.19	0.86
AM users	19	116.13 (9.55)	46.84 (31.20)	-0.38	0.86
EP users	27	118.46 (9.77)	27.80 (12.20)	-0.20	0.48
No strategy	14	113.64 (10.93)	40.80 (26.80)	-0.13	0.98